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Contents

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OBSERVATIONS CONCERNING THE LIFE CYCLE OF SPONGOMORPHA COALITA (RUPRECHT) COLLINS

G. J. Hollenberg

The work of Smith (1947) showed that in *Spongomorpha coalita* all plants are sexual, producing biflagellate gametes only. Smith concluded that this species of *Spongomorpha* does not exhibit an isomorphic alternation of generations. He observed that zygotes are negatively phototropic but did not follow their development.

During the summers of 1953–1956 inclusive the writer made culture studies of this plant at the Hopkins Marine Station at Pacific Grove, California. The cultures were kept in a cool humid basement room with northern light at 16–20° C. Discharge of gametes was obtained in a manner similar to that described by Smith. Advantage was taken of the negative phototactic response of the fusing gametes, also described by Smith, in getting cultures of zygotes relatively free of diatoms. The culture solution was sea water which had been heated nearly to the boiling point and allowed to cool. Nutrients were added as described for previous cultures by the writer (Hollenberg, 1939).

The zygotes are very small, measuring mostly 3–4 µ in diameter. Smith states that the gametes lack a pyrenoid. The writer likewise observed no pyrenoid in the gametes, but very young germlings (figs. 1–3) showed two distinct pyrenoids. At this stage the chromatophore seemed to be of a reticulate nature. Perhaps more than one was present.

Within a few days it became evident that the original outgrowth of the zygote, which forms during germination, constituted a colorless rhizoidal outgrowth. Within two or three weeks it seemed apparent that this rhizoidal outgrowth represented some sort of attachment or penetration organ (figs. 3–6). Growth of the unicellular structure was very slow and no cross walls appeared, but as the rhizoidal process elongated the original cell became more or less spherical and gradually enlarged. When about 30 days old many of the germlings had become as much as 30 µ in diameter, with thick walls and dense chromatophore with a number of pyrenoids (fig. 6). The rhizoidal process was up to 100 µ long and mostly very contorted.

Although the pigmented cells increased slightly more in diameter, they seemed to become dormant and in most cases finally died or were overrun with diatoms. However, the culture started on July 19, 1955, remained alive until October 29, 1955, when it was discovered that several branching multicellular plants had developed from the unicellular germlings on the squares of cover glass in the culture dishes. The cells of these plants contained each a reticulate chloroplast and a number of pyrenoids. One of these plants had reached a length of 2 millimeters, but unfortunately the culture had become so overgrown with diatoms that the diminutive

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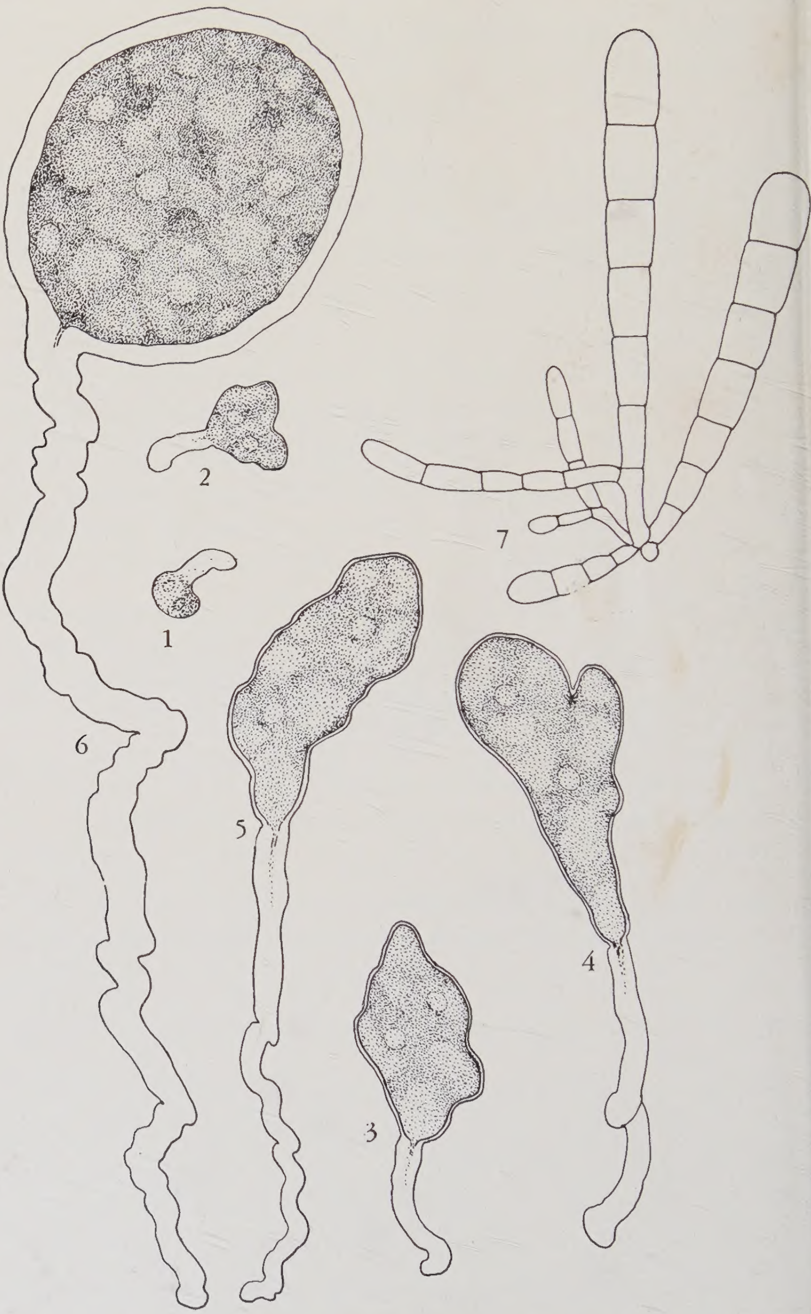

FIGS. 1–6. Stages in the germination and growth of zygotes of *Spongomorpha coalita*, $\times$ 1600.
FIG. 7. Multicellular plantlet developing from a *Spongomorpha* zygote, $\times$ 35.

plants soon died. Since these multicellular plants developed directly from the bulbous part of the unicellular germlings on the pieces of coverglass, no free-swimming zoospores were involved in their development under the particular culture conditions.

In the cultures of the following summer no multicellular plants were obtained.

The slow growth and seeming dormancy of the zygotes and the development of the rhizoidal outgrowth, as well as the fact that the germlings continued to remain unicellular, suggested early in this study that they were probably some endophyte such as *Codiolum*. Several unsuccessful efforts were made to find *Codiolum* during the summer season in order to explore a possible relationship of this plant to *Codiolum*. Possibly *Codiolum* is seasonal in its appearance.

The failure to find zoospores arising from the unicellular germlings, and the failure of the multicellular plants arising in the cultures to develop to the stage in which the characteristic hooks arise on the branches, leaves some gaps in the suggested life cycle, but there seems to be little reason to doubt that the multicellular branched plants were young *Spongomorpha* plants. However, the culture studies on this plant have been discontinued because another investigator, Kung Chu Fan, is studying this problem. His more conclusive studies will be reported in the literature soon. Preliminary reports of Fan's work (1957) and that of the writer (Hollenberg, 1957) have been previously given.

It should also be noted that Jónsson (1957) has shown that a life cycle similar to the one suggested above for *Spongomorpha* occurs in the case of a closely related genus *Acrosiphonia*.

In summary, the above study shows that zygotes of *Spongomorpha coalita* developed slowly in the cultures into unicellular germlings with contorted rhizoidal outgrowths and that some of the germlings gave rise to branched multicellular plants believed to represent young *Spongomorpha* plants. The unicellular stage is believed to be an endophyte similar to or identical with *Codiolum*.

Department of Biology,
University of Redlands,
Redlands, California.

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ABERRANT AMARANTHUS POPULATIONS OF THE SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

John M. Tucker and Jonathan D. Sauer

In the early 1890's W. L. Jepson found some tall, brightly colored amaranths growing among other rank vegetation on the riverbanks and small islands of the lower Sacramento River (Jepson, 1893, p. 243; 1914, p. 449; also Table 1). Although these were growing in natural habitats, he interpreted them as feral derivatives of an introduced cultigen which he identified as *Amaranthus hypochondriacus* L. We believe that Jepson was right in looking toward cultivated ornamental species for an ancestor of these striking plants, but their ancestry is different and more complex than he thought.

At present similar robust amaranths, on occasion attaining heights of as much as nine feet, often with gaudy anthocyanin pigmentation and great compound inflorescences, grow widely through the lowlands above the junction of the two major Central Valley rivers. They can still be found along the river side of levees but are now far more abundant as weeds in cultivated fields. It is apparent that they occur in very large part on the highly organic, peaty, basin soils—Staten peaty muck, Venice peaty muck, and Egbert muck—occupying the bulk of the delta country, as well as on more limited areas of alluvium—Burns clay loam, Ryde clay loam, Sacramento loam. They are abundant up to the edge of the peat soil and then peter out rapidly on the generally more alkaline alluvial loams along the periphery of the delta area.

Morphology

Field observation and examination of the few conventional herbarium specimens available from the area (Table 1) established that the delta amaranths are highly variable and include individuals that resemble various recognized species but rarely appear identical with any of them. In one population or another through this region characters of five different species are discernible, although in no population yet studied are the characters of all five present. These are all rather closely related members of the section *Amaranthotypus* Dumort. Descriptions and diagrammatic figures illustrating diagnostic features of these species are presented elsewhere (Sauer, 1950). It will suffice here to tabulate briefly the typical condition, or norm, of each species in four important structures (Table 2).

Population Samples

In order to get beyond the frustration and uncertainty that come with attempts to understand taxonomically difficult populations from a few isolated specimens, mass collections were made at widely scattered localities through the delta (Table 1). Individuals were collected at random in sufficient numbers to give a respectable sample of the actual popula-

TABLE 1. ABERRANT AMARANTHUS COLLECTIONS FROM THE DELTA AREA

COLLECTOR AND NUMBER (DATE)	HERBARIUM (ACCESSION)	HABITAT AND LOCALITY	POSTULATED PARENTAGE
		Conventional Herbarium Specimens	
W. L. Jepson (Oct. 4, 1893)	JEPS	Tyler Island, Sacramento County	*A. cruentus* x *A. retroflexus*
W. L. Jepson (Oct., 1895)	UC (7574)	Lower Sacramento	*A. cruentus* x *A. retroflexus*
R. N. Raynor (Aug. 11, 1941)	DAV (51)	Asparagus field, near Clarksburg, Yolo County	*A. caudatus* x *A. retroflexus*
C. O. Sauer and J. D. Sauer *1502* (Oct., 1947)	WIS	Roadside levee, Sherman Island, Sacramento County	*A. cruentus* x *A. powellii* x *A. retroflexus*
J. D. Sauer *1643* (Aug. 14, 1953)	DAV, WIS	Farmyard ditch, Roberts Island, San Joaquin County	*A. caudatus* x *A. hybridus* x *A. powellii*
		Population Samples	
J. M. Tucker *2314* (Oct. 31, 1951) 14 individuals	DAV, WIS	Periphery of cornfield, Staten Island, San Joaquin County	*A. caudatus* x *A. powellii* x *A. retroflexus*
J. M. Tucker *2335* to *2343* (March 29, 1952)	DAV	Progeny of certain individuals from previous collection (2314) grown in greenhouse.	
J. M. Tucker *3277* (Oct. 27, 1956) 17 individuals	DAV	Milo field 1 mile west of Thornton, San Joaquin County	*A. cruentus* x *A. powellii* x *A. retroflexus*
J. M. Tucker *3278* (Oct. 27, 1956) 47 individuals	DAV, WIS	Asparagus field 2½ miles west of Thornton, San Joaquin County	*A. cruentus* x *A. powellii* x *A. retroflexus*
J. M. Tucker *3279* (Nov. 10, 1956) 16 individuals	DAV	Asparagus field, Roberts Island, San Joaquin County	*A. cruentus* x *A. powellii* x *A. retroflexus*
J. M. Tucker *3280* (Nov. 10, 1956) 21 individuals	DAV, WIS	Open field, Union Island, San Joaquin County	*A. hybridus* x *A. powellii* x *A. retroflexus*

tion. In most cases only a few inches of the terminal portion of the inflorescence was collected and pressed. From some of these open-pollinated individuals progenies were grown in the greenhouse which, in cases where the number of individuals was small, were studied in their entirety, or, where the number of individuals was large, in random samples.

Each individual specimen was scored for its degree of resemblance to the five species in Table 2 in the characteristics tabulated. Discrimination between these taxa relies heavily on shape differences in the almost microscopic flower parts. It is practically impossible to abstract these effectively by simple measurements, but they can be scored by comparison with a graded series of specimens used as standards. These scorings have been rechecked and found to be repeatable with only minor variation.

Table 2. Diagnostic Characteristics of the Species Involved in the Delta Amaranth Complex

	Tepal	Bract	Utricle	Inflorescenc
A. caudatus	Long, very broadly obovate or spatulate, tip obtuse or emarginate, recurved.	Short or medium length, midrib very slender, rather long excurrent.	Style-branches recurved with slender bases forming shallow saddle.	Thick and pendul terminal spike extremely long, laterals few and l short or absent.
A. cruentus	Extremely short, oblong, tip acute, straight.	Extremely short, midrib extremely slender, long excurrent.	Style-branches erect with slender bases forming sharp cleft at summit of very narrow tower.	Moderately thick very lax, termina spike short, latera long, extremely numerous and crowded.
A. hybridus	Medium length, oblong, tip acute, straight.	Moderately long, midrib medium thick, long excurrent.	Style-branches erect with slender bases forming sharp cleft at summit of moderately narrow tower.	Moderately slend lax, terminal spik short, laterals short, numerous, and crowded.
A. powellii	Very long, oblong, tip acute, straight.	Extremely long, midrib very thick, excurrent.	Style-branches recurved with stout bases forming cleft at summit of broad tower.	Thick and stiff, terminal spike long, laterals long, few and widely spaced.
A. retroflexus	Very long, narrowly obovate, tip emarginate, recurved.	Extremely long, midrib extremely thick, barely excurrent.	Style-branches erect with moderately stout bases forming saddle or shallow cleft.	Extremely thick and stiff, termina spike short, laterals short, numerous, and crowded.

Data obtained in this way are presented in figures 1 to 3. Each small triangle represents an individual plant; its position relative to the apices of the grid indicates in a relative way resemblance to any of three species; the barbs on each symbol show scoring of separate diagnostic characters; shading inside the symbol indicates a peculiarity which is not taxonomically diagnostic. A detailed legend is given with figure 1. For example, in collection *2314* there are four plants shown in the lower left corner; all of these resemble *A. powellii* S. Wats. in all four characters studied, more than they resemble the other two species involved, but one plant slightly resembles *A. retroflexus* L. in all four characters and another slightly resembles *A. caudatus* L. in its bract structure. Toward the lower right corner of the same grid are two highly sterile plants which resemble *A. caudatus* more than *A. retroflexus* in tepal structure, but are closer to *A. retroflexus* in the other three characters.

In three of the population samples listed in Table 1 (Tucker *3277*, *3278*, and *3279*) the same species were involved—*A. cruentus* L., *A. powellii*, and *A. retroflexus*. Since results of the analyses were quite similar in all three, only one (*3278*) is shown graphically (fig. 3).

It is evident from these graphs that the delta amaranth populations have variation patterns which are intelligible but extraordinarily complex. Instead of the monotonous repetition of character sets found in ordinary species sampling, these collections show reshuffling in a rich variety of individual combinations of several character sets. Characters of two species, *A. retroflexus* and *A. powellii*, recur in each field collection, while a third element alternates between characters of *A. hybridus* L., *A. cruentus*, and *A. caudatus*. Fortunately for the task of graphic representation, populations with more than three elements have not yet been encountered!

Discussion

Recent hybridization between the five species mentioned seems the best explanation of the genesis of these populations. There is a loose but definite tendency for characters in the intermediate individuals to associate in the same combinations that are constant in the extremes—the recognized species. This is evidence of recent gene recombination hindered by old linkages that were established during more effective breeding discontinuity. This discontinuity may have resulted primarily from the former geographic segregation of the species, discussed below. If so, spatial isolation has been reinforced by secondary sterility barriers. High sterility is common in raw hybrids between *Amaranthus* species. For example, Murray (1940, p. 416), in many experimental interspecific crosses, obtained almost sterile F_1's bearing only a few seeds to an entire inflorescence. Some of these crosses involved species in the delta complex—*A. caudatus*, *A. hybridus*, *A. powellii*, and *A. retroflexus*.[1]

Highly sterile plants, similar morphologically to certain of Murray's specimens, occur sporadically in the delta populations, but some apparent hybrids are not at all sterile. At first glance this recovery of fertility suggests amphidiploidy, but actually the hybrids must have regained fertility by some more subtle mechanism. Several progenies (from *Tucker 2314*, *3278*, etc.) have been examined cytologically by Dr. Walter Plaut of the University of Wisconsin and Dr. W. F. Grant of McGill University and found to have the usual *Amaranthus* diploid number.

Another peculiarity which emerges in many individual delta amaranths is failure of the mature utricle to dehisce. Each of the field collections contains both dehiscent and indehiscent types; offspring of known "mother" plants usually but not always are like their mothers in this respect. Indehiscent utricles are an anomaly among all the species involved here. There are other sections of the genus in which indehiscence is the rule, but there is no trace of their other characteristics in these populations.

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[1] In referring to this work it is necessary to revise a few of the original species determinations (Sauer, 1953).

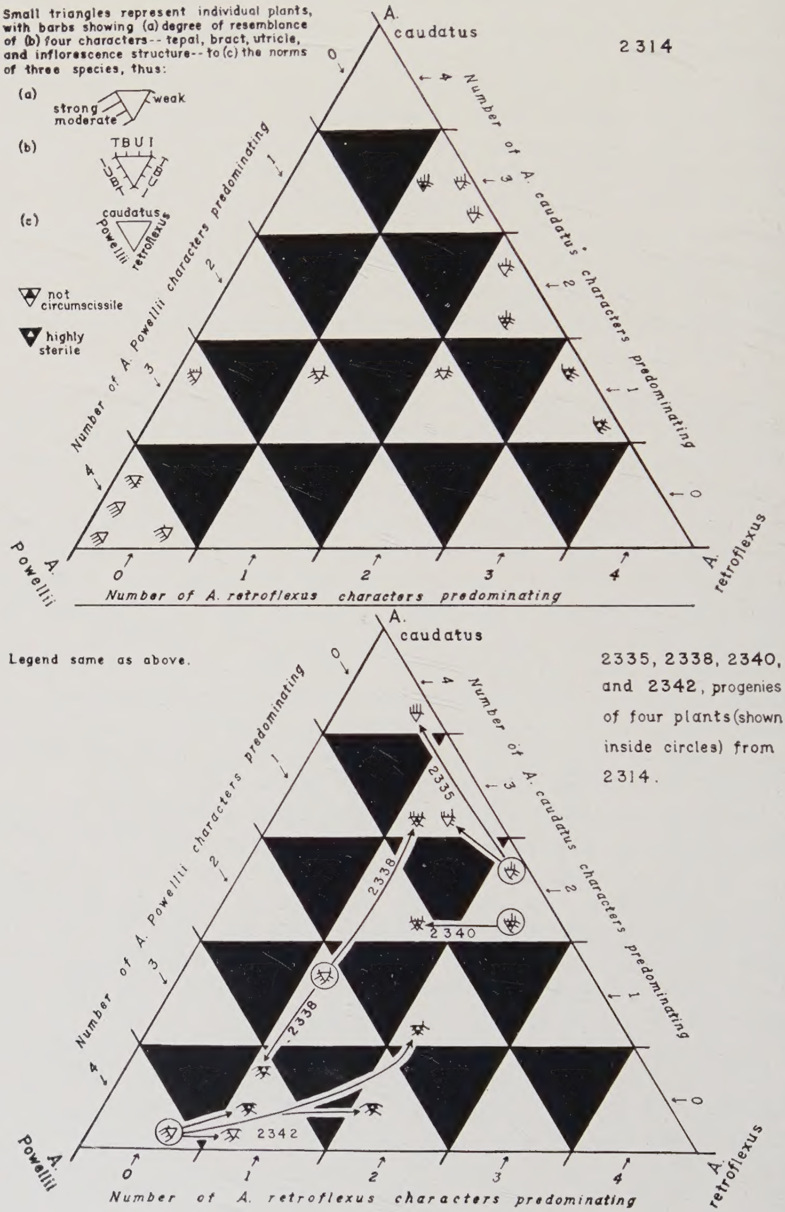

FIG. 1. Character combinations in a delta amaranth population sample, and in progenies of four of its members.

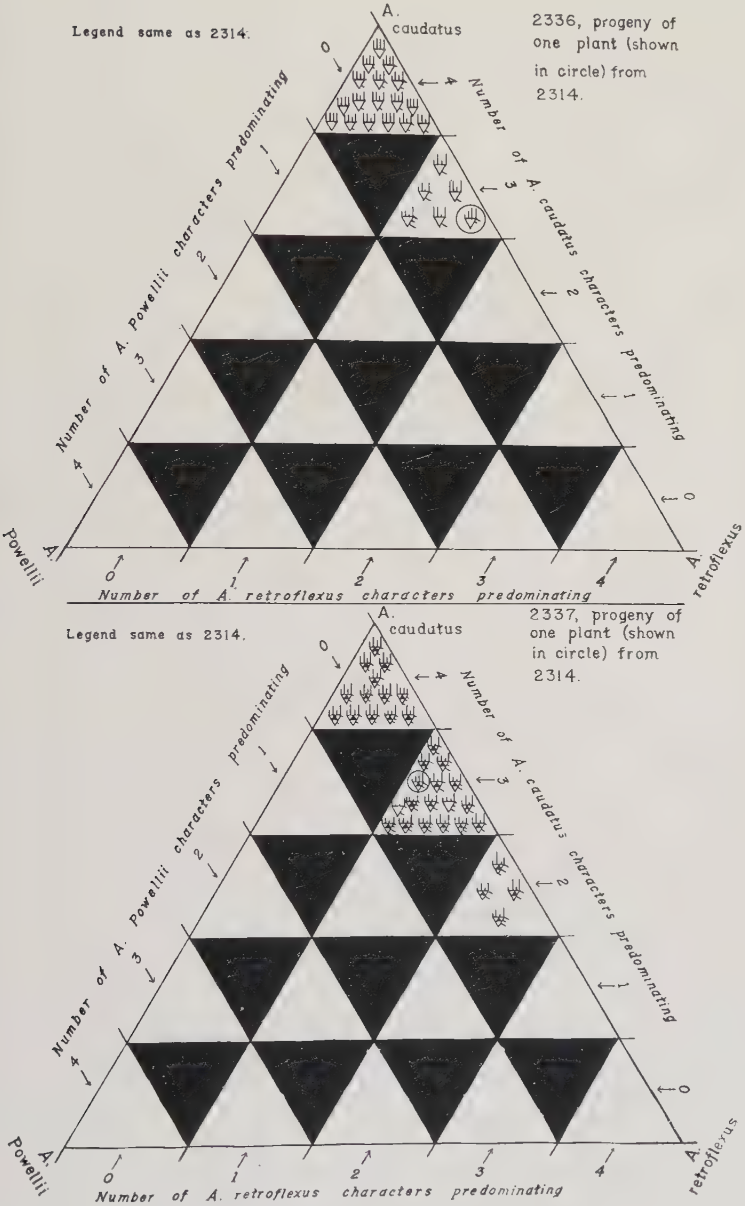

FIG. 2. Character combinations in progenies of delta amaranths.

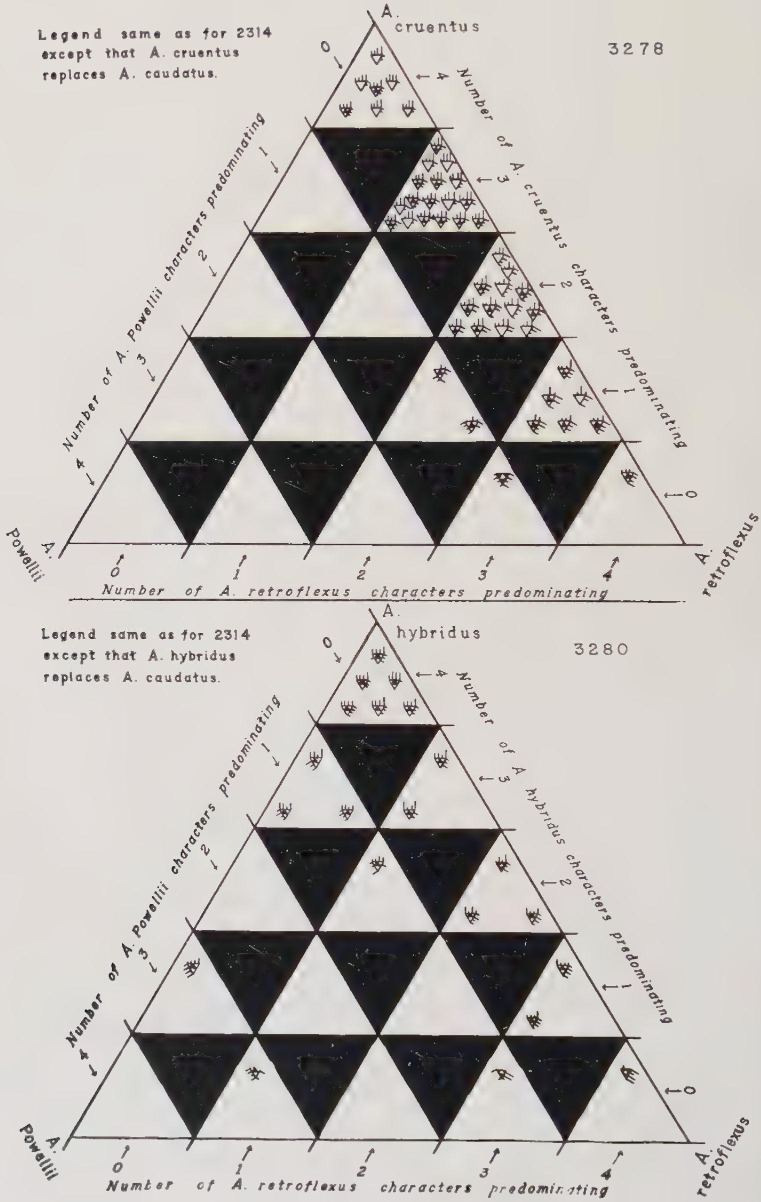

FIG. 3. Character combinations in delta amaranth population samples.

It seems likely that indehiscence in this group should not be regarded as a positive character traceable as a unit to distant ancestral species, but rather as simply a loss or breakdown of the mechanism controlling circumscission of the utricle in some hybrid genotypes. Thellung (1926) proposed the name *A. bouchoni* for similar plants which turned up as adventives in Europe, but he expressed uncertainty as to whether he was dealing with a new species or merely a form of ordinary *A. hybridus*. A heterogeneous lot of similar plants have been collected in many parts of the world. In the herbarium they mostly bear, perhaps properly, the name of some ordinary dehiscent species which they closely resemble.

Four of the five species which have joined forces in the delta area are natives of distant regions of America (Sauer, 1950). Only *A. powellii* appears to be native to the western United States. It is now mainly a weed of artificial habitats, but it is still found in what may have been its original habitat: naturally open sites along stream channels. It is conceivable that it was in the delta area in aboriginal times and has merely spread locally as the tule marshes were converted to modern farms.

The other species are probably late arrivals whose appearance in the delta country could hardly have antedated its opening to agricultural exploitation. The earliest attempt to reclaim any of this tule land for cultivation was evidently in the late 1850's (Hoag, 1872, p. 338), when a few farmers settled on Sherman Island, the southwestern extremity of present-day Sacramento County. The phenomenal productiveness of the fertile peat soil and California's Swampland Act of 1861 encouraged the reclamation of additional areas (Calif. Dept. Public Works, Div. Water Resources, 1931, p. 157). Results of early efforts were often temporary, however, and only about 15,000 acres had been reclaimed by 1870. During the next decade the area increased apace, and by 1880 a total of about 107,000 acres had been reclaimed. Reclamation continued at a fairly rapid pace to as late as 1920 (*op. cit.*, p. 158).

Other amaranth species have been found among the vegetable remains in old adobe bricks from the California mission period (Hendry and Bellue, 1925), and one of our species, *A. retroflexus*, was reported from 18th century bricks of Tumacacori Mission in Arizona (Hendry, 1931, p. 117). Other early reports of *A. retroflexus* and *A. hybridus* can be found in California botanical literature, but in the absence of contrary evidence from actual specimens such records may show nothing but taxonomic confusion. Early botanists were slow to recognize the western *A. powellii* as distinct from superficially similar eastern species, and in older herbarium determinations *A. powellii* usually masquerades as *A. retroflexus* or *A. hybridus*. In the 1890's *A. retroflexus, A. cruentus,* and *A. caudatus* begin to join *A. powellii* in the herbarium record from California; *A. hybridus* appears after 1900.

The backgrounds of these immigrants are diverse. *Amaranthus hybridus* probably originated in tropical America; it is now the commonest weed amaranth there and in the southeastern United States. Contrary to

oft-repeated statements in taxonomic manuals, *A. retroflexus* is unknown in the tropics; it is a conspicuously successful weed in eastern Canada and the eastern United States, where it probably originated. Although centered much farther north, its range widely overlaps that of *A. hybridus*. *Amaranthus cruentus* and *A. caudatus* are cultigens, developed as grain crops by ancient Indian peoples of Central America and the Andes, respectively. *Amaranthus cruentus* was apparently derived from *A. hybridus*, *A. caudatus* from *A. quitensis* H.B.K., a species not known to be present in California. Both of these old Indian crop species have been widely distributed as ornamentals, often by commercial seed houses.

The introduction of these weedy and ornamental amaranths into California is in no way remarkable—all of them have immigrated into many parts of the world in modern times. Nor is the mere fact of hybridization between these species especially noteworthy. Two things do, however, impress us as being quite remarkable: firstly, the fact that the introduced ornamentals have not begotten just a few ephemeral escapes and abortive hybrids as is the rule elsewhere, but rather have made a spectacular contribution to successful weed populations. Secondly, despite their evident success in the delta country, these ornamentals and their hybrids have not spread beyond the area, but seem to be rather closely confined to it.

The two facts are in all probability closely interrelated. As with so many of man's vegetable creations, in the case of the two cultigens, *A. caudatus* and *A. cruentus*, selection has most likely been for rapid growth, large size, and high yield, *given* cultivation, *given* fertile soil, and *given* a moisture supply through the growing season. Whatever drought resistance their ancestors may have had, whatever ability to flourish under adverse soil conditions—most of this may well have been lost long since. As with the cultigen species, so with their hybrids in the delta region. Given a light and highly fertile organic soil,[2] a constant moisture supply, due to a high water table, and a long, warm growing season, these hybrids, by virtue of their more robust stature and often prodigious fecundity, can out-compete—as field weeds—their ruderal parents, *A. hybridus*, *A. powellii*, and *A. retroflexus*. However, the very circumstance of their ornamental parents' having evolved as cultigens is the undoing of the hybrids under conditions much less than optimal, keeping them from successfully invading areas that lack the highly organic soil, abundant moisture, and other favorable conditions which prevail in the delta.

[2] After four years of experimental work on improving asparagus yields, G. C. Hanna (1939) had found no fertilizer which would improve yields on Ryer Island soils!

Department of Botany,
University of California, Davis
and
Department of Botany,
University of Wisconsin, Madison

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THE GENUS ERYSIMUM (CRUCIFERAE) IN NORTH AMERICA NORTH OF MEXICO—A KEY TO THE SPECIES AND VARIETIES

George B. Rossbach

This key to twenty-three species and eight varieties of *Erysimum* is a result of detailed analysis of the specimens in various American herbaria plus collections of the writer from areas throughout most of the range of these taxa in the United States. Many morphological interrelationships exist among the various taxa, these usually manifesting themselves as local geographical forms which presumably have a genetical-ecological basis. Some of these forms are of sufficient magnitude to be treated as varietal entities. In a careful attempt to express much of this variability in the key, it frequently has been necessary to rely for identification upon a combination of many characteristics, to refer to exceptions and make cross-references, and to key three taxa twice. However, with understanding of the diagnostic characteristics and realization of the close relationships, the great majority of plants can be relegated to reasonably definite taxa. In order to present a survey of geographical distribution, a summary of the range of each taxon is added to the key.

Although the genus is native south through Mexico into Guatemala, taxa presumably limited to these countries are omitted due to insufficient representation. Thus at least two probably acceptable Mexican species,

Erysimum Tilimi J. Gay and *E. macradenium* J. Gay, are excluded from this key. Forms of *E. capitatum* (Dougl.) Greene, *E. insulare* Greene, and possible forms of *E. argillosum* (Greene) Rydb. also occur in Mexico as well as northward.

A. Petals small, 3–13 mm. long, just under 1–5 mm. broad; seeds 2 mm. long or much shorter, 1 mm. broad or narrower.
B. Annuals.
C. Axis of mature raceme geniculate; siliques divaricate, (4–)6–8(–8.5) cm. long, moniliform at maturity; pedicels consistently short, under ⅓ as long as siliques, nearly as thick as siliques, 1–1.5 mm. thick; margins of leaves repand-dentate. Widespread weed from Europe........................*E. repandum* L.
CC. Axis of mature raceme straight; siliques more or less ascending, very short, (1–)1.5–2(–3.5) cm. long, not moniliform, plump; pedicels of various lengths, ⅓ to ½ as long as siliques, much more slender than siliques, not over and usually under 0.6 mm. thick; margins of leaves sparingly denticulate, often some entire. Widespread, often as a weed, native and from Europe...*E. cheiranthoides* L.
BB. Biennials or short-lived perennials, the latter usually at high altitudes, far north or coastal.
D. Siliques 2–3 cm. long as known in North America, in Europe also to about 10 cm.; cauline leaves sparingly and shallowly denticulate on our plants. Weed from Europe, known in Ontario and Quebec............*E. hieracifolium* L.
DD. Siliques 4–10 cm. long, rarely less; cauline leaves usually entire.
E. Petals 1–3 mm. broad; lower leaves often broadly and usually bluntly oblanceolate, broadest very near apex, not callose.
F. Leaves usually cinereous, sometimes not so in cooler environments, as locally in northwest portion of range, usually not crowded; stems almost always single, or if more than one, usually strict; petals usually pale yellow, usually under 10 mm. long, usually 2 mm. or less broad. Great Lakes (local), to Nevada and Alaska...*E. inconspicuum* (S. Wats.) MacMill.
FF. Leaves not at all or scarcely cinereous, usually crowded; stems often more than one, spreading-ascending; petals usually rich yellow, usually 10 mm. or more long, 2 mm. or more broad. Local on Gulf of St. Lawrence and Newfoundland...*E. inconspicuum* var. *coarctatum* (Fern.) G. B. Rossbach[1]
EE. Petals 3–5 mm. broad, as known; lower leaves narrowly elongate, linear-oblanceolate, acute or subacute, callose. Known locally from desert of southern New Mexico . . . *E. desertorum* (Woot. & Standl.) G. B. Rossbach
AA. Petals larger, 13–32 mm. long, rarely as short as 7 mm. (P–PP), (3–)+3–15 mm. broad; seeds larger, usually 2 mm. or more long, usually 1 mm. or more broad (except J).
G. Leaves never approaching a filiform shape, some or all as much as 2 or more mm. broad.
H. Plants not suffrutescent, the caudex not notably elongate or long-branched above ground, erect, or at least not sprawling or widely spreading, sterile branches absent, or if present, very short, not elongate; lowest leaves dropping, breaking or long-lived, but scarcely marcescent. A few plants tending toward characters of HH.
I. Seeds wingless or bearing a small scarious distal appendage, very slightly to convexly compressed, variously shaped; siliques equally tetragonal to

[1] The taxa attributed to the author were published as follows: Rossbach, George B. 1958. New taxa and new combinations in the genus Erysimum in North America. El Aliso 4:115–124.

strongly compressed, equally to very unequally keeled. Not occurring on coast.

J. Siliques very rigidly divaricate, equally or subequally tetragonal, with subequal, very protrusive keels prominent as four dark, less pubescent stripes; seeds small, about 1.5 mm. long, scarcely compressed, rather angular, almost always wingless; leaves narrowly oblanceolate, some or all dentate; foliar hairs crowded, quite strigose, 2-parted; stems rather low, commonly under 30 cm. to base of raceme. Great Plains, Black Hills, local prairie extensions into Rocky Mountains........................ ....*E. asperum* (Nutt.) DC.

JJ. Siliques ascending, occasionally becoming arching-divaricate when long and heavy, usually compressed, but ranging from subequally tetragonal to strongly compressed, very unequally to subequally keeled, not notably striped; seeds of variable size, more or less compressed, winged or wingless; leaves and stems variable.

K. Leaves narrow, acute or subacute, usually thick, revolute and cinereous; foliar hairs 2-parted, usually crowded; siliques narrow, commonly about 1.5 mm. broad, subequally tetragonal to slightly compressed, most often subequally keeled, hairs usually crowded; seeds wingless or less often minutely winged, commonly not over 2 mm. long; petals yellow; stems usually low, commonly 8–30 cm. to base of raceme. Dry regions, mid-altitudes, mainly Rocky Mountains, Great Basin to eastern California, southwestern plateaus.................... ....*E. argillosum* (Greene) Rydb.

KK. Combination of characters not as above; foliar hairs 2– or 3–parted; siliques compressed, unequally keeled; otherwise variable.

L. Some or all upper foliar hairs 3– or more parted, 2–parted hairs frequently also present, or locally in Southwest the hairs exclusively 2-parted; leaves usually dentate or denticulate, subacute to acute; siliques fairly protrusively keeled on flatter surfaces; seeds distally winged; fresh petals usually orange, also shades of yellow, brick-red, orange-brown, or locally in Southwest a purplish maroon, drying toward purple; stems usually tall, commonly 20–70(–135) cm. to base of raceme. Widespread, largely inland in hills, mainly Pacific states and east into Idaho, through southwestern states and locally east to Texas and northeast to Ohio; Mexico and southern British Columbia.........*E. capitatum* (Dougl.) Greene

LL. Combination of characters not as above; foliar hairs usually but not always 2-parted; leaves variable; siliques with very slender, scarcely or non-protrusive keels on flattened surfaces; seeds variable; petals yellow, or some orange-yellow, or rose-red-purple (UU and TT); stems variable.

M. Stems, except for impoverished individuals, robust and much-branched above, diameter near base commonly 4–12 mm., usually tall, about 12–60 cm. to base of raceme; foliar hairs usually dominantly 2-parted; seeds long, 2–4 mm., noticeably winged at distal end.

N. Leaves elongate, linear-lanceolate, tapering gradually to quite acute apex, dentate, green; siliques slender, (1.5–)-2(–2) mm. broad, seeds remote; caudex somewhat prolonged; stems tall, commonly 30–60 cm. to base of major raceme, usually near 5 mm. in diameter at base. Dunes by San Joaquin River east of Antioch, California... ....*E. capitatum* var. *angustatum* (Greene) G. B. Rossbach

NN. Leaves oblanceolate, rather blunt, entire or very sparingly and minutely denticulate, cinereous; siliques broad, 2–2.5 (–3) mm. across; seeds proximate; caudex not prolonged; stems usually shorter, over 5 mm. in diameter at base except for impoverished individuals. Mojave Desert and locally on edge of Carrizo Plain, California..
..........***E. capitatum* var. *Bealianum*** (Jepson) G. B. Rossbach

MM. Stems slender, simple or occasionally sparsely or much (Q) branched, diameter near base under 4 mm., usually much less, usually low, about 0.5–22 (–50: O, S) cm. to base of raceme; otherwise variable.

O. Plants not dwarf, stems slender, tall, 30–50 cm. to base ot raceme, green or dull purplish green, usually bearing very small abortive axillary branches; leaves narrowly elongate, acute, (4–)6–9(–18) cm. long, (1–)2–5(–9) mm. broad; siliques long, slender, compressed, often purplish green, (6–)8–10(–13) cm. long, about 1.3–1.8 mm. broad; fresh petals orange to orange-yellow. See also E′E′. Sandy mesas near Lompoc, Nipomo, and Guadalupe, California ....
.........................*E. suffrutescens* var. *lompocense* G. B. Rossbach

OO. Plants dwarf, stems almost always under 20 cm. to base of raceme (some exceptions, S); otherwise variable.

P. Leaves runcinate-dentate, linear-lanceolate to narrowly oblanceolate; foliar hairs 2–3-parted; petals always yellow.

Q. Stems often several, major ones or all divaricately and rigidly long-branched; leaves cinereous, callose, basal ones drying by flowering time; siliques not purplish colored, not notably moniliform, not torulose. Deposits about hot springs south of Reno, Nevada..
.........................*E. capitatum* var. *washoense* G. B. Rossbach

QQ. Stems single or less often several, almost always simple, the branches, if any, few, ascending, short, not rigid; leaves green, not callose, basal ones living through flowering time; siliques purplish colored, moniliform, often slightly torulose. Upper Mount Rainier, less typically on several other mountains of northwestern Washington........
....*E. torulosum* Piper

PP. Leaves entire, not of one general shape, if dentate, usually broadly oblanceolate, or if linear and dentate, the petals usually rose-red-purple; foliar hairs usually 2-parted; petals yellow or purple.

R. Leaves broadest very near apex, spatulate to oblanceolate, apex rounded, blunt or broadly angular; foliar hairs variable; sterile leaf rosettes present or absent.

S. Siliques not torulose, scarcely or not moniliform, commonly 2–3 mm. broad, tapering gradually to varying degrees; style variably long, more or less slender, about 0.5 mm. thick; lower leaves spatulate to bluntly oblanceolate, not acute, entire or less often very sparingly denticuate or dentate; foliar hairs usually or dominantly 2-parted; caudex simple or shortly branched, rarely bearing sterile leaf rosettes; stems variable in height, (0.5–)2–30(–50) cm. to base of raceme. High mountains, Sierra Nevada and very locally north and east......
............................*E. perenne* (S. Wats. in Coville) Abrams

SS. Siliques torulose, curved in several planes, moniliform, not over 2 mm. broad, tapering very gradually and slenderly; style long, very slender, almost always under 0.5 mm. thick; lower leaves very shortly and broadly oblanceolate, not rounded, dentate; foliar hairs 2- often dominantly 3-parted; caudex multicipitous, becoming elongate if buried, bearing some sterile leaf rosettes; stems always low, 4–13 cm. to base of raceme. Known in alpine zone on Mount Steele and Mount Constance, Olympic Mountains, Washington....*E. arenicola* S. Wats.

RR. Leaves not broadest very near apex, linear-lanceolate to oblanceolate, acute; foliar hairs 2-parted; sterile leaf rosettes often present.

T. Petals yellow or rose-red-purple; raceme leafless and bractless.

U. Foliar hairs crowded, strigose; very crowded leaves eventually marcescent on lower portions of stems, entire or very nearly so; petals yellow; seeds very elongate, 2–2.3 mm. long, 0.7 mm. broad. Known from vicinity of Dawson, Yukon...*E. angustatum* Rydb.

UU. Foliar hairs almost always sparse and delicate; leaves not marcescent, entire or few times dentate or denticulate; petals rose-red-purple or yellow; seeds obovate, 1.5–2 mm. long, 1–1.6 mm. broad. High altitudes in Rocky Mountains, most frequent in Colorado............................*E. nivale* (Greene) Rydb.

TT. Petals always rose-red-purple; few to many of the lower pedicels subtended by or bearing bracts or leaves.

V. Stems very low, (-1–)1–3(–5) cm. to base of raceme; leaves entire or very sparingly and shallowly dentate; only lowest few pedicels subtended by bracts. Widespread in arctic North America and Asia...*E. Pallasii* (Pursh) Fern.

VV. Stems taller, (8–)15–16(–18) cm. to base of raceme; lower leaves numerously and deeply dentate; many pedicels substended by or some bearing a bract or small leaf. Known from Teller. western coast of Alaska........*E. Pallasii* var. *bracteosum* G. B. Rossbach

II. Seeds extensively winged about distal end and more or less along one side, strongly compressed, oval; siliques, at least when dry, very strongly compressed, unequally keeled.

W. Style long, (2–)3(–5) mm.; leaves entire or occasionally sparingly denticulate, linear-oblanceolate, cinereous. Sands along middle Columdia River and nearby on tributaries....*E. occidentale* (S. Wats.) Robins.

WW. Style shorter, scarcely present to 1(–2) mm. long; leaves variable, but not cinereous except in a northern form (Y). Coastal or near coast, or in case of *E. Cheiri* raised in gardens.

X. Siliques stiffly divaricate, upcurved except for a few colonies not on dunes (under or near YY); pedicels divaricate.

Y. Leaves oblong-spatulate or at least blunt, broadest toward base of stem, where measuring 4–13 (rarely –30) mm. broad; stems low, (1–)3–7(–13) cm. to base of raceme. Local on coastal dunes on and near Point Pinos, and Fort Bragg to several miles north, and on west side Humboldt Bay, California..*E. Menziesii* (Hook.) Wettst.

YY. Leaves linear-oblanceolate to oblanceolate, acute, becoming narrowly elongate toward base of stem, 1.5–3 (rarely –6) mm. broad; stems almost always taller, (3–)15–50(–83) cm. to base of raceme. Coastal sands along Monterey Bay; atypical forms along San Diego County and Santa Rosa Island, California.. *E. ammophilum* Heller

XX. Siliques stiffly ascending, straight to slightly upcurved (though sometimes becoming arching-divaricate when long and lax); pedicels variable.

Z. Stigma not bicornate, merely bilobed; leaves not soon deciduous, almost always regularly sinuate-dentate; foliar hairs usually dominantly 3-parted; petals rich yellow, yellow, or creamy white.

A′. Leaves shortly oblanceolate, abruptly contracted to apex; siliques distally blunt or at least tapering abruptly to style; plants fleshy. Restricted to coastline, on bluffs and headlands, atypically and rarely on nearby dunes, locally from Point Reyes, Marin County, California, to The Heads, Curry County, Oregon.. *E. concinnum* Eastw.

A′A′. Leaves linear-oblanceolate, elongate, almost always tapering rather gradually at both ends; siliques usually tapering gradually to style; plants not fleshy, sometimes very locally the coastal plants slightly so. See D′ for unusual forms. Serpentine or sandy soil, near and only very locally on the coast, San Mateo County, and vicinity Mount Tamalpais, and at least formerly at Bodega Bay, California, and near mouth of Rogue River, Curry County, Oregon.. *E. franciscanum* G. B. Rossbach

ZZ. Stigma bicornate, i.e. deeply divided, with long arching lobes; leaves always soon and progressively deciduous along the aging stout stem, entire or very sparingly and sharply serrulate-denticulate; foliar hairs 2-parted; petals variable in color, yellow, orange, brown-orange or with purplish hue. See also C′. Introduced from Europe, rarely persistent or escaped from gardens.. *E. Cheiri* (L.) Crantz

HH. Plants suffrutescent, the caudex elongate, long-branched above ground, sprawling or widely spreading, bearing elongate sterile branches; leaves (except under C′) becoming marcescent below. (A few plants tend toward characters of H.)

B′. Seeds strongly compressed, extensively winged more or less along one side as well as about distal end; siliques compressed.

C′. Stigma bicornate, i.e. deeply divided, with long arching lobes; leaves always soon and progressively deciduous along aging stem, entire or very sparingly and sharply serrulate-denticulate; foliar hairs 2-parted; petals variable in color, yellow, orange, brown-orange, or with purplish hue. See also ZZ. Not coastal in the Americas, introduced from Europe, rarely persistent or escaped from gardens.. *E. Cheiri* (L.) Crantz

C′C′. Stigma not bicornate, only slightly 2-lobed; leaves not usually deciduous below, but more or less marcescent, almost always regularly sinuate-dentate; foliar hairs (2–)3(–many)-parted; petals rich yellow, yellow, or occasionally creamy white. Coastal or near-coastal.

D′. Plants not fleshy, sometimes very locally the coastal plants slightly so; these unusual forms moderately suffrutescent and the sterile branches, if present, usually short; siliques usually tapering gradually to style, not fleshy, strongly compressed; style 1–2 mm. long; seeds not usually crowded; petals colored as above. See A′A′ for

usual forms. Serpentine or sandy soil, near and only very locally on the coast, San Mateo County and vicinity Mount Tamalpais, and at least formerly at Bodega Bay, California, and near mouth of Rogue River, Curry County, Oregon............*E. franciscanum* G. B. Rossbach

D′D′. Plants succulent; becoming suffrutescent, usually sprawling and branched and bearing some sterile stems; siliques tapering abruptly to style, fleshy, plump, but strongly compressed when dry; style -1(–1.8) mm. long; seeds usually crowded, often irregular in shape; petals rich egg-yellow. Coastal bluffs and headlands locally along San Mateo County and on near-coastal sandy slope in Santa Cruz County, California....*E. franciscanum* var. *crassifolium* G. B. Rossbach

B′B′. Seeds not strongly compressed, convex, distally winged or wingless; siliques variable.

E.′ Plants succulent, notably suffrutescent and sprawling-ascending, or sometimes spreading-upcurved (F′), much-branched, bearing long vegetative stems; leaves notably marcescent below; siliques coarse, squarish in cross-section or compressed variously, either at right angles to or parallel to septum.

F′. Plants suffrutescent, branched, usually spreading-upcurved; leaves narrowly linear-oblanceolate, (1.5–)2–3(–5–rarely 6) mm. broad; siliques compressed parallel to septum or squarish in cross-section. Coastal sands, southern Santa Monica Bay, and from Santa Maria River to southern Morro Bay, California...*E. suffrutescens* (Abrams) G. B. Rossbach

F′F′. Plants strongly suffrutescent, much-branched, sprawling at base; leaves variable; siliques plump, abruptly contracted at both ends, replete with crowded, irregular seeds, squarish in cross-section to compressed at right angles to septum.

G′. Leaves comparatively broad, 3–12(–20) mm. broad, tending toward two types, one large and abruptly tapering to blunt apex, not recurved, often terminating sterile branches, the other narrower, more gradually tapering, recurved, occurring at any location, usually fleshier; foliar hairs sparse, (2–)3(–4)-parted. Coastal dunes between Arguello and Purisima points, and rocky maritime bluffs of Morro Rock near Morro Bay, California..................................*E. suffrutescens* var. *grandifolium* G. B. Rossbach

G′G′. Leaves all narrow, 1.5–3(–5) mm. broad, essentially of one type; foliar hairs crowded, 2-parted. San Miguel and Santa Rosa islands of the North Channel Islands, California, and a form with somewhat blunt, smaller leaves on Guadalupe Island, Baja California ....*E. insulare* Greene

E′E′. Plants not at all fleshy, only moderately suffrutescent, not sprawling, only once or few-times branched, bearing few and rather short sterile stems; leaves only moderately marcescent below; siliques slender, always quite compressed parallel to septum. See also O. Sandy mesas near Lompoc, Nipomo, and Guadalupe, California..*E. suffrutescens* var. *lompocense* G. B. Rossbach

GG. Leaves nearly filiform, 0.3–1.7 mm. broad; stems suffused with somewhat metallic purplish hue, normally simple; caudex more or less elongate, herbaceous to subligneous, single or divided. Miocene Santa Margarita sand deposit in Santa Cruz Mountains, California..................................*E. teretifolium* Eastw.

West Virginia Wesleyan College,
Buckhannon, West Virginia

DR. JOHN McLOUGHLIN AND THE BOTANY OF THE PACIFIC NORTHWEST

Erwin F. Lange

Among the unrecognized contributors to the development of the botany of the Pacific Northwest is Dr. John McLoughlin, Chief Factor for the Hudson's Bay Company from 1824 to 1846 with headquarters at Fort Vancouver, situated on the northern bank of the Columbia River, 120 miles inland from the Pacific Ocean. From Fort Vancouver, McLoughlin ruled with dictatorial authority an empire that extended from California to Alaska and from the Rocky Mountains to the Pacific Ocean and which was inhabited only by savage Indians and white fur traders. Also at Fort Vancouver he was awarded the first medal for botany to be presented in the Pacific Northwest.

During these years the region was a virgin wilderness with the forts of the fur traders providing the only haven to which a weary traveller might turn for some degree of civilized comfort. The botany of the area was unexplored and challenged scientists of both America and Europe. Without the cooperation of the officials of the Fur Company the collecting of the new and interesting plants of the Northwest would have been delayed for many years. Of particular interest to the scientific history of the Pacific Northwest is the fact that all of the early botanical explorers were welcomed by Dr. McLoughlin so that during his years as Chief Factor, Fort Vancouver became in effect the scientific headquarters of what was then known as the Oregon Country.

In April, 1825, the first two scientists to explore extensively in the Pacific Northwest arrived from England just as McLoughlin was moving his headquarters from Fort George, Astoria, to Vancouver. These were Dr. John Scouler, naturalist, and ship surgeon on the Hudson's Bay Company's *William and Anne*, and David Douglas, botanist sent by the Horticultural Society of London.

Dr. Scouler remained in the Northwest but a few months collecting zoological and botanical specimens, and on his return to England he was the first scientist to describe in British scientific journals the practice of the Chinook Indians of flattening the skull of infants of the Indian aristocracy. Scouler met McLoughlin at Fort George and wrote of him in his dairy:

> From him I experienced the utmost politeness and to his kindness was indebted for some curious specimens of the rocks of the Rocky Mountains.

David Douglas, one of the most prolific botanical collectors of the Pacific Northwest, explored much of the Oregon Country during the years 1825–1827 and 1832–1833. His explorations were interrupted by a return journey to England.

On first meeting McLoughlin he noted in his diary:

FIG. 1. Dr. John McLoughlin. Portrait made about 1845. Courtesy of the Oregon Historical Society.

> . . . I embarked in a small boat with Mr. John McLoughlin, the Chief Factor, who received me with demonstrations of the most kindly feelings, and showed me every civility which it was in his power to bestow.

Douglas showed McLoughlin his written instructions from the Horticultural Society and discussed his plans verbally. As a result of the conversation, Douglas wrote:

> In the most frank and handsome manner he assured me that everything in his power would be done to promote the views of the society.

Fort Vancouver became the headquarters for Douglas as he radiated out in all directions to collect seeds, pressed specimens and living plants of an unknown and exciting flora. The Fort was used to dry and prepare his specimens, and pack them for shipment to England on board the ships of the Hudson's Bay Company. Dr. McLoughlin made all facilities of the Fort available to him including boats and horses for transportation.

Fig. 2. Fort Vancouver, 1845. Courtesy of the Oregon Historical Society.

For cooperating in promoting the study of botany in the Pacific Northwest, Dr. McLoughlin was awarded a silver medal by the Horticultural Society of London on May 11, 1826. This medal was the first scientific award made in the Oregon Country and is today on exhibit in the McLoughlin house, a public shrine, in Oregon City, Oregon. The *Transactions of the Horticultural Society* refer to the awarding of the medal as follows:

> To John McLoughlan [sic], the Chief Factor of the Hudson's Bay Company, at the mouth of the River Columbia, for his assistance rendered Mr. David Douglas, whilst making his collections in the countries belonging to the Hudson's Bay Company in the Western part of North America.

After taking his final leave from the Oregon Country Douglas, whose name is today popularly associated with the Northwest's most important lumbering tree, the so-called Douglas fir, summarized the status of science in this wild country:

> Science has few friends among those who visit the coast of North-West America, solely with a view to gain. Still with such a person as Mr. McLoughlin on the Columbia, they may do a great deal of service to Natural History.

The first two scientists to travel across the American continent reached Fort Vancouver in September, 1834. They were Thomas Nuttall, botanist and naturalist, who resigned his position at Harvard University in order to accompany Nathaniel Wyeth on his second overland expedition, and J. Kirk Townsend, a young Philadelphia ornithologist. Although Nuttall and Townsend had accompanied Wyeth who was attempting the establishment of a rival fur company under American auspices, they were well received by Dr. McLoughlin at Fort Vancouver.

Townsend recorded the events of the expedition in a delightful narrative in which he frequently referred to the activities of Dr. McLoughlin. Although he did not record any particular act of hospitality at the Fort, his account indicates that he and Nuttall were frequent and welcomed visitors. Actually for several months Townsend was placed in charge of the hospital of Fort Vancouver and he acted as physician in the absence of a regular company medical doctor. The only account of Nuttall's activities on this expedition was recorded by Townsend in his narrative. Although Nuttall kept a diary on other occasions, no diary of his trip to the Oregon Country is known at the present time. He described his plant collection of the Northwest in the *Transactions of the American Philosophical Society* in 1840. Nuttall's name is particularly perpetuated in the region by the beautiful flowering dogwood (*Cornus nuttallii*) named by the famous ornithologist James Audubon.

The greatest array of scientists to visit McLoughlin at Fort Vancouver was the members of the United States Exploring Expedition under the command of Lieutenant Charles Wilkes. The expeditionary forces had been split up in making surveys in various areas of the Pacific Ocean so that they arrived at different times during the summer months of 1841. The narrative of the expedition by Commander Wilkes contains numerous references to and descriptions of Dr. McLoughlin and Fort Vancouver. The hospitality shown Wilkes was recorded as follows:

> He is a tall fine-looking person of a very robust frame, with a frank manly open countenance, and a florid complexion; his hair is perfectly white. He gave us that kind reception we had been led to expect from his well-known hospitality . . . . He at once ordered dinner for us, and we soon felt ourselves at home, having comfortable rooms assigned us, and being treated as part of the establishment.

A few days later McLoughlin provided Wilkes with a large river barge, fully provisioned, so that he could adequately explore the Willamette River.

William D. Brackenridge, horticulturist of the expedition, likewise was impressed with McLoughlin, his gardens, and his orchards. Of this he wrote:

> I can say but little, having spent only a few hours with the principal, Dr. McLoughlin, who in the most friendly manner showed me around his gardens.

The botanical collection of the Wilkes expedition was described by Dr. Asa Gray. One large volume of 777 pages and atlas was published in 1854 and another volume remains unpublished. The ferns and fern allies were described by Brackenridge in a 357-page volume with atlas, also in 1854.

An overland exploring expedition under Captain John C. Fremont was organized to coordinate the inland exploration with the activities of the Wilkes expedition. On November 8, 1843, Captain Fremont arrived at Fort Vancouver and in his report of the expedition recounted the meeting with Dr. McLoughlin:

> I immediately waited upon Dr. McLoughlin, the executive officer of the Hudson Bay Company in the territory west of the Rocky Mountains, who received me with

the courtesy and hospitality for which he has been eminently distinguished, and which makes a forcible and delightful impression on a traveller from the long wilderness from which we had issued. . . . . but every hospitable attention was extended to me, and I accepted an invitation to take a room in the fort, "and to make myself at home while I staid."

The plants collected by Fremont were described by Dr. John Torrey in 1854 in a volume of the *Smithsonian Contributions to Knowledge* and also in Fremont's report.

This account could easily be lengthened by quoting records of other acts of hospitality administered by the well-known Chief Factor of the Hudson's Bay Company. Also, it could be pointed out that McLoughlin's employees, particularly the medical doctors of the Fort, made important discoveries in botany and natural history. Their books constituted the first science library in the Pacific Northwest. However, another important contribution of McLoughlin to science must not be overlooked; his control over the native Indians which made the wild forests relatively safe for the pioneer scientific explorers.

Dr. McLoughlin, as supreme ruler of the Pacific Northwest, was a strict disciplinarian who combatted Indian crimes with stern justice. H. H. Bancroft in his *History of the Northwest Coast* described McLoughlin's unusual influence over the savage mind. Before McLoughlin's time it was not safe to travel far except in armed bands. After McLoughlin's time as Chief Factor, the history of the Pacific Northwest is marked by brutal massacres and bloody Indian wars which took the lives of many white settlers. However, Bancroft pointed out that McLoughlin:

. . . . achieved by his wise and humane policy a bloodless revolution, savage foes metamorphosed into steadfast friends, a wilderness teeming with treachery into a garden of safe repose.

While much has been written of McLoughlin and thousands of people each year visit his historic home, his contributions to the sciences, particularly the botany, of the Pacific Northwest have been entirely ignored by historical writers. September 3, 1957, marked the centennial of the death of the once mighty ruler of the Oregon Country and it is proper that the scientific world take slight note of a great friend.

Portland State College
Portland, Oregon

REVIEWS

Native Plants for California Gardens. By LEE W. LENZ. ix + 166 pp., frontispiece (color photograph), 100 halftone illustrations. 1956. Published by Rancho Santa Ana Botanic Garden. For sale at Abbey Garden Press, Pasadena, California. $3.85.

According to the foreword: "This book is the outgrowth of a series of papers devoted to the botany and horticulture of California plants, published as the Leaflets of Popular Information by the Rancho Santa Ana Botanic Garden. An attempt has been made to select from the native flora those species which can be recommended as of value to gardeners, described them in simple language and giving their cultural

requirements as well as suggested uses in California landscaping and gardening. In order to make the identification of the plants easy for those not already familiar with them, the majority of the species are illustrated."

Four chapters set the background for the body of the book. These treat respectively the uniqueness and diversity of the California flora, early collectors, landscaping uses of natives, and procedures in garden culture. Of the four, unquestionably the information in the first chapter is the most basic for anyone not already intimately acquainted with the topography, climate, soils, and major plant communities of California. Nowhere is it more true than in transferring native plants from their indigenous environment to the artificial conditions of a garden that, "For what we obtain of *Nature,* we must not do it by commanding, but by courting of her." Although considerable information is presented, even more could have been included in the first chapter with profit.

The second chapter surveys botanical and horticultural collectors of the period 1769 to about 1906. Some readers will appreciate this information, some will pass it over. On the horticultural side one wishes the period might have been extended to the date of publication in order to have included several pioneer collectors who should not be omitted in any history of the introduction of natives to California.

The third chapter is largely a tabular cross-index to the landscape uses of those plants which are discussed in detail later in the book.

The fourth offers recommendations on propagation and handling. It is written especially for the person who is unfamiliar with both general techniques of propagation and the particular plant materials. The author has chosen to meet the needs of such a gardener by being concrete and specific rather than by developing general principles in greater detail. As with any approach there are advantages and disadvantages. Much of the data on plant materials in this chapter is a recapitulation of the information on propagation given under each species in the body of the book.

The body of the book is a formal treatment of 101 species with generous references to additional related ones. Most of the species selected are ornamentals although a few, such as *Aristolochia californica* and *Chorizanthe staticoides*, are curiosities or have only limited horticultural values. Some 50 per cent are shrubs, 35 per cent annuals and perennials, and the remaining 15 per cent are equally distributed between trees, vines and bulbs. Nearly four-fifths of the shrubs and a third of the other species are limited to the southern part of the state in natural occurrence. The caption of each species treatment includes not only scientific and common name but a figure representing maximum height — a very helpful position for this information. The material itself is organized under: Description, Distribution, Propagation, Flowerng (omitted for annuals and perennial herbs), Uses, and comments (no heading). The description is botanical, that is, for identification, rather than horticultural for characterization. Distribution is stated briefly, propagation expanded. While uses refer to landscape uses, in some cases recommendations as to where in California the plant can or cannot be grown are included. The only pertinent topic one misses in the treatment of species is that of natural associates, for natives are grown most conveniently with other natives; however, some glimpse of associates will be found in the introductory chapter on the California flora. Excellent black and white photographs, chiefly the work of M. and M. Carothers, accompany the section. The author is to be congratulated on not having followed any slavish plan in the illustrations, but of letting the nature of the plant dictate how it could be portrayed most effectively.

Even though the brief literature list at the end of the book is not intended to be exhaustive, it indicates how little has been written in this field and how grateful the reader can be for the present contribution. The only serious omissions in this list are the two excellent volumes of Lester Rowntree, "Hardy Californians" (1936) and "Native California Shrubs and Their Value to the Gardener" (1939).

"Native Plants for California Gardens" takes its place on the gardener's reference shelf as the first book on California natives in the encyclopedic style, the first predominantly on natives of and for southern California, the first effort to compile

and coördinate experiences of the staff of the Rancho Santa Ana Botanic Garden of native California plants (formerly located at Santa Ana, now at Claremont, California) into one handy volume for the interested public. It presents a large amount of information in readily accessible, clearly organized form and is enhanced by excellent illustrations.—Helen-Mar Wheeler, Department of Botany, University of California, Berkeley.

Plant Classification. By Lyman Benson. xiv + 688 pp., 399 illustrs. 1957. D. C. Heath and Company, Boston. $9.00.

This is a notably handsome book. The nearly 400 illustrations, including serviceable diagramatic sketches by the author, beautifully conceived and executed analytical representations of plant families by the talented late Jerome D. Laudermilk, and well chosen photographs of natural vegetation, occupy approximately as much space as the text.

The bulk of the text (more than 300 pages) is devoted to a systematic treatment of the vascular plants—dicotyledons, monocotyledons, gymnosperms, and pteridophytes, in that order. All 80 orders of living vascular plants recognized here are keyed, as are the 332 families accepted. Chief emphasis is placed upon dicotyledons, for which the author has perfected a new five-fold system stated to be based upon "relationships" but not "purported phylogeny." The principal groups are Thalamiflorae, Corolliflorae, Calyciflorae, Ovariflorae, and Amentiferae; "the Amentiferae appear to be mostly an artificial group, and they are retained as a unit because their relationships still are not settled . . . the other four are more natural than artificial." The author believes that students should build their understanding of plant relationships around a concept of how close, or how far removed, the plant in question is from the Ranales. His groupings are designed to facilitate the development of such a concept.

Each synopsis of a class of plants appears under the heading, "The Process of Identification"; it is preceded by one or more chapters entitled, "The Vocabulary Describing . . . Characteristics," which is an illustrated résumé of the gross morphology of the particular group. This feature is strikingly reminiscent of Gray's classical "Lessons in Botany," and gives especial appropriateness to the beautiful photograph of "the father of North American botany," clad in field clothes, which serves as frontispiece.

After the encyclopaedic description of each class, there follows one or more chapters on "The Basis of Classification," which comprise a rather mixed assortment. Under angiosperms there is a chapter on "Evolution," consisting largely of a formal justification of the theory, and there is also a short section on "The Development of New Taxa"—by differentiation and isolation. Further chapters discuss "Some Fundamental Problems of Plant Classification" (method of segregating taxa, relative stability of characters), a sketch of the history of plant-classification systems, a comparison of the more recent schemes, and an exposition of the bases of the system adopted by the author.

This last chapter, summarizing the work of I. W. Bailey and his associates and students as evidence for the primitiveness of Ranales, is very promising, but its effect is considerably subdued by its relegation to pages 475 to 486. Moreover, the retention of the undoubtedly artificial and reduced "Amentiferae" as a group and of such features as a wholly artificial arrangement of fruits (based upon "fleshy" vs. "dry") and of the term "pistil," which is difficult to homologize with the evolutionary modification of megasporophylls into carpels, as discussed elsewhere in the volume, further diminish the impact.

The living gymnosperms are divided among four classes: Conopsida, Ephedropsida, Gnetopsida, and Cycadopsida. Their classification, apparently based upon a résumé of their presumed geological history, contains no reference to the work of either Sahni or that of Florin. The pteridophytes are treated similarly.

The last section deals with the "Association of Species in Natural Vegetation," and gives a descriptive sketch of North American plants under nine "floras" and a short though useful bibliography. In the middle of the book is a rather detached chapter on "Preparation and Preservation of Plant Specimens." The appendix includes a guide to favorable collecting seasons in different parts of the continent and a useful glossary.

The volume, despite its many excellent features, is difficult to sum up. The stressing of keys, identification, groupings, taxonomic hierarchy, descriptions, and collection of specimens definitely places emphasis on the *materials* of taxonomy. The arrangement of major groups, despite the chapter on evolution and that on the basis for the author's preferred system, suggests that convenience takes priority over the operations of those biological phenomena which make patterns of diversity inevitable and classification feasible. The book is designed as an elementary text for college students "*without prequisite,*" and is based on the view that the path to an appreciation of the world of plants lies primarily through learning their names and positions.—LINCOLN CONSTANCE, Department of Botany, University of California, Berkeley.

The Mushroom Hunter's Field Guide. By ALEXANDER H. SMITH. 197 pp., 1 figure, 124 photographs. 1958. University of Michigan Press, Ann Arbor. $4.95.

In his introduction, Dr. Smith states that since he is concerned with mushrooms most easily identified by their pictures, illustrations are the backbone of this handbook; for each species illustrated, he includes a discussion of the important field characters rather than a formal description of the species characters. In making this book a field guide, he adds that he has sacrificed scientific accuracy, but he has pointed out in the text where it can be attained. His intention has been to illustrate the mushrooms in such a way as to enable accurate recognition and emphasize the critical characters.

In my opinion, Dr. Smith has achieved his purpose—that is, to write a field guide that would enable mushroom hunters to make accurate identifications and protect them against serious errors—more completely than one could have expected in a book of this size and simplicity. No knowledge of botany is required in order to use this guide; all that is necessary is careful observation and caution in collecting, as well as compliance with Dr. Smith's recommendations to discard all specimens that do not completely fit the descriptions and to exercise care in cooking and eating. This is a handbook that can be recommended without any hesitation and without cautionary advice to the amateur collector, since the author enumerates clearly all the dangers involved in the gathering of mushrooms for the table. The book is a good size and shape for use in the field. The photographs are excellent.

The book is intended for the Great Lakes region, northeastern United States and western United States. It includes a list of fifteen species considered safe for beginners, a list of species associated with certain trees, and a seasonal list of common mushrooms. Although only about one in thirty species in the United States is included, most of the common mushrooms, the finest of the edible species, and the most dangerous of the poisonous species are discussed and illustrated. In addition, the guide includes some of the mushrooms that are poisonous only to certain people. The introductory section includes a brief account of the role of fungi in the breakdown of organic substances, their manner of growth, nutritional and moisture requirements, and mycorrhizal relationships. The structure of fleshy fungi is also discussed, as well as variation in form, precautions to take in collecting, and the nature of Latin binomial names. Instructions are given in the use of the simplified key; a glossary and a short bibliography are also included.—ISABELLE I. TAVARES, Department of Botany, University of California, Berkeley.

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Classified entries: Chromosome numbers, Reviews. New scientific names are in boldface type. Un-annotated taxa in floral lists are omitted from Index.